

Brine

What is Brine?

Brine is defined as any liquid that is saturated or nearly full of chloride. This could mean that any dry chemical freeze point depressant that contains chlorides, such as Magnesium Chloride, Sodium Chloride, Potassium Chloride or Calcium Chloride when mixed with a liquid would be considered a brine. For the purposes of this discussion, we will concentrate on a brine made from the mixture of sodium chloride (rock salt) and water. This is the brine most often used in the state of Iowa for prewetting and anti-icing operations.

Why Brine?

Brine has been used in many European countries for many years as both a prewetting agent for dry materials and as an anti-icing agent for the proactive treatment of snow and ice. For prewetting there are two methods commonly used to wet the dry freeze point depressant before it is placed on the roadway:

1. Brine can be sprayed over the load while in the vehicle just prior to use. This requires an overhead sprayer device capable of delivering a strong stream of liquid uniformly over the load.
2. Brine can be sprayed onto the dry materials just as it leaves the truck or just prior to contact with the pavement by direct application at the spinner or auger.

For anti icing, the key is to place the brine on the roadway surface prior to a precipitation event. This action helps prevent the snow and ice from bonding to the pavement. The City of Oskaloosa was an early advocate of anti-icing as a way to keep snow and ice from bonding to the road surface. They have also used it with great success on city sidewalks. The following article, written in 1995, explain how the City began using brine in their operations:

Saltwater solution aids in controlling ice buildup on city streets

article in APWA publication

On December 8, 1995, the Oskaloosa Public Works Department started using a new method of controlling ice buildup on our most heavily-traveled city streets.

A city truck with a large yellow tank was used to apply a saltwater solution to the streets before an ice storm hit. Oskaloosa was the first city in the state of Iowa to employ this system, and while the idea for it came from the Iowa State Department of Transportation (IDOT), the equipment to apply it was entirely homegrown

The traditional way street departments deal with ice and ice/snow conditions is to apply salt or salt/sand mixtures on top of an accumulation of ice and/or snow This top-down melting uses large amounts of salt, and sometimes results in saltwater puddles. These concentrations of saltwater contribute to auto body damage, especially on older cars.

The new system, which was developed jointly by Iowa State University and the IDOT, attacks the problem from underneath, that is, a saltwater solution is applied onto the dry pavement, melting the ice and snow from the bottom up This has several benefits'

- 1) It takes a very small amount of salt to prepare the solution. (meaning cheaper)*
- 2) It attacks the problem at the source, that is where the ice meets the road.*
- 3) It continues working and carries over between storms*
- 4) It allows for increased manpower utilization, because the solution can be prepared and stored ahead of time*
- 5) It keeps the salt away from your car better than traditional methods.*
- 6) It leaves no sand residue behind that has to be removed from storm sewer catch basins or swept up and disposed of in the spring by our city's street sweeping equipment. The Inspiration for this concept goes back to a state-sponsored snow conference in October, attended by several key public works people.*

IDOT in West Des Moines has been experimenting with this newly-developed system for about three years. Out of their experience, a pilot program was developed at the Council Bluffs DOT, where the Council Bluffs technicians developed a low cost method of applying the liquid Two representatives of Oskaloosa Public Works visited with both West Des Moines and Council Bluffs DOT officials. viewed their respective systems and decided to seek authorization to build the local system.

Using salvage materials and agricultural valves and piping sources locally from Oskaloosa farm and hardware stores, Public Works personnel built a saltwater generating facility and application system at the city shop. While West Des Moines is evaluating a federally-sponsored \$28,000 prototype application system, Oskaloosa built the complete saltwater generating and application system for less than \$3,000. It is estimated that the system has largely paid for itself in reduced salt usage during two storms alone

While the system does not address all of the challenges facing snow and ice control, it goes a long way toward reducing the costs, and increasing the effectiveness of our annual battle against winter driving hazards.

Public Works crews will still be plowing, scooping, and clearing snow They will still be applying sand/salt mixes when needed at intersections to help motorists stop The liquid application isn't the answer to all possible situations, but it will reduce winter operating costs, and give city workers one more weapon against ice, which will help make Oskaloosa a safer place to drive.

Dan Kalbach- Oskaloosa

Now, over seven years after this article was written, the use of salt brine for prewetting and anti-icing is no longer experimental or unusual. In the winter of 2002-2003, the Iowa Department of Transportation used over seven million gallons of brine. All of the Iowa DOT's snow plow trucks are equipped with units that prewet dry materials at the spinner. Anti-icing equipment is available to anti-ice the entire commercial and industrial network (over 9,000 lane miles) when conditions make it an effective strategy. Many cities and counties, including many of the major metro areas are now active users of salt brine.

Traditional practices depended on rock salt or mixtures of rock salt and abrasives to remove snow and ice from the roadways. The materials were delivered from the bed of the truck to a spinner where it could be widely dispersed onto the pavement. The idea was to concentrate much of the chemical over the middle of the roadway so that as the chemicals began the melting process the melting liquid would

move away from the crown of the roadway to the lower levels of the roadway and help break the snow and ice bond with the pavement. A study conducted by the Michigan Department of Transportation measured the amount of chemicals left on the roadway after a typical spinner application of materials and found that nearly 30% of the materials left the roadway after application and landed on shoulders or in ditches due to bouncing (delete paragraph break) With a typical Iowa DOT application of 300 pounds per lane mile of a 50/50 mix of salt and abrasives, that would mean that once the truck passes **only** 210 pounds of the mix remains on the roadway.

Further studies conducted in Switzerland and Germany also measured the amount of dry chemicals that remained on the roadway after vehicle movement and found that after 5 vehicles had passed, only 30 percent of the dry materials remained on the roadway. After 100 vehicles, only 20 percent of the dry chemicals remained to do the job. When the materials were prewet, after five vehicles had passed, 93 percent of the materials remained on the road and after 100 vehicles, 80 percent remained on the roadway surface. If a dry 50/50 mix is being used to remove snow and ice it is obvious that a roadway with large volumes of traffic will quickly lose most of the materials onto the shoulder or ditch where it is of little help to melt snow and ice.

Advantages of using brine for prewetting:

- Rock salt can be spread more uniformly and less is wasted on shoulders and ditches reducing the impact to the environment
- Materials adhere to the surface because the salt & brine mixture has a thicker consistency. The slurry-like mixture tends to “plop” onto the roadway and better stay where it lands.
- Melting begins faster since a liquid has been introduced to the salt. (Salt must find moisture before it can begin to work)
- Spreading speeds can be increased because more material stays on the roadway
- Since the brine begins working and diluting as it hits the surface, it will dry much more rapidly, returning the roadway to normal winter driving conditions much sooner.
- Residual salt may remain on the road that will immediately begin working with the next storm
- When dry materials are prewet with brine, the application rate can actually be cut back 20-30% because more of the material remains on the roadway. In addition, the additional brine adds some quick melting action.
- Can be used as a deicer on very thin layers of frost or black ice, but with caution. Salt brine is not recommended for snow pack unless it is treated regularly and frequently with a sufficient quantity of salt brine and or salt brine and rock salt. Brine alone will rapidly dilute and if an insufficient concentration is maintained, may refreeze before it can burrow through the snow or ice pack

Advantages of using brine for Anti icing:

- Application prior to a storm can help prevent the snow and ice from bonding to the pavement. Helps keep roadway wet longer into a storm or in the case of a very light precipitation event, possibly throughout the storm.
- Makes clean-up quicker and returns roads to normal driving conditions more rapidly

- Reduces labor hours
- Reduces wear on ice blades and underbody plows

Cost Savings

The following chart helps describe the cost saving that might be expected when using brine as a prewetting agent:

Assumptions

Salt	\$30 per ton
50/50 mix	\$19 per ton
Brine	\$.05 per gallon

Prewet at 15 gallons per ton of dry material

If a 50/50 (salt/sand) mix is applied at 300 pounds per lane mile on a 40 lane mile route.

Costs without prewetting

- 6 tons of material used at \$19/ton= \$114

Costs with prewetting assuming application rate is reduced by 25% (225 lbs per lane mile):

- 4.5 tons of dry material at \$19/ton= \$85.50
- 68 gallons of brine at \$0.05/gal= 3.40
- Total Costs= \$88.90

Total Savings= \$25.10

If straight salt is applied at 200 pounds per lane mile on a 40 lane mile route the savings would be as follows :

Costs without prewetting:

- 4 tons of material used at \$30/ton= \$120

Costs with prewetting assuming application rate is reduced by 25% (150 lbs per lane mile):

- 3 tons of dry material at \$30/ton= \$90.00
- 45 gallons of brine at \$0.05/gal= 2.25
- Total Costs= \$92.25

Total Savings= \$27.75

It doesn't take long to recognize that for larger operations the savings can be significant over a period of time.

If you choose to prewet and not reduce the application rates, service levels will improve since more material remains on the roadway to melt snow and ice and less would be found (and wasted) in the ditches or shoulders.

How to make Brine:

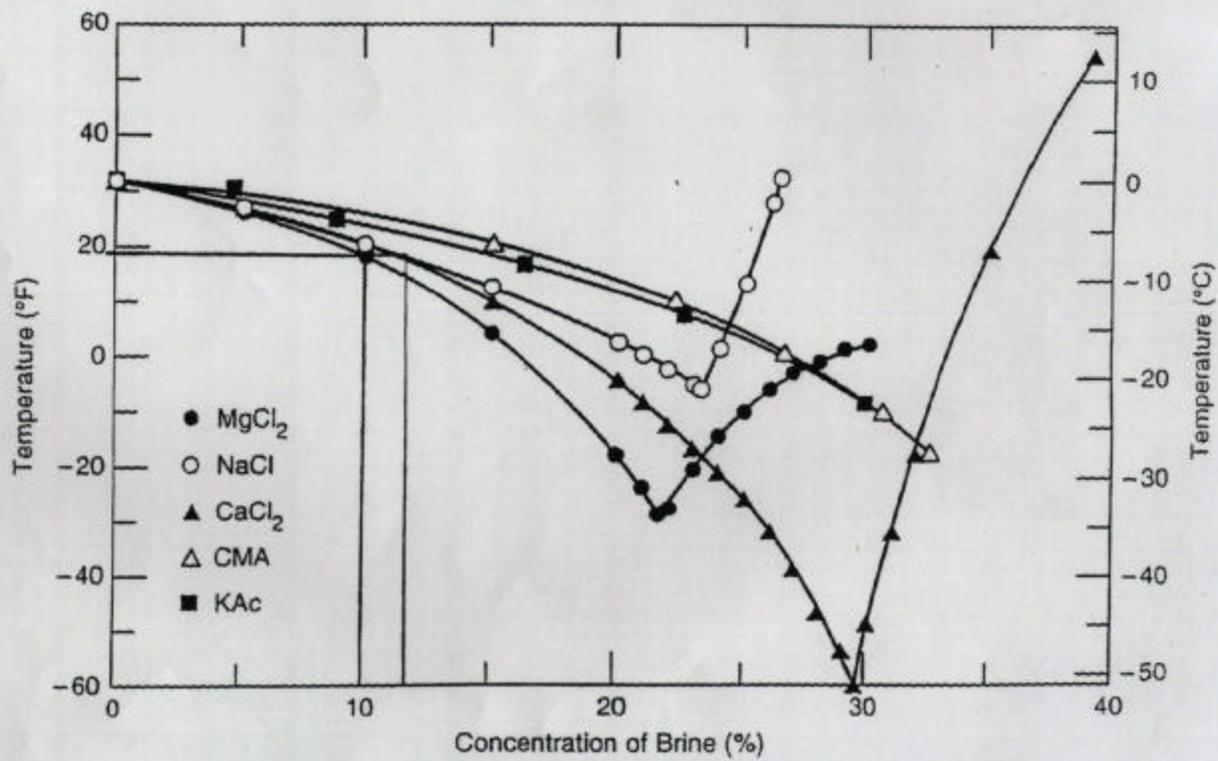
Making brine is a fairly simple process that requires only two ingredients - water and salt. Of course a container to mix the materials properly and storage tanks are also required. To achieve the ideal concentration of 23.3% you will also need a hydrometer or salimeter that can measure the quantity of salt, by weight, in the brine concentration. Hydrometers can be purchased with readouts in specific gravity, percent solution or salt concentration.



Hydrometer used to measure salt solution

If the concentration of salt is too high or too low the temperature when the concentration freezes will be much higher than at the ideal 23.3% concentration. It is very similar to adding anti freeze to a vehicle. Water freezes at 32 degrees and straight anti freeze freezes at 2 degrees but when they are mixed at 30 percent water and 70 percent anti freeze, the freezing temperature of the two ingredients mixed together becomes **-84** degrees. As the percent of anti freeze is increased or decreased from the ideal percentage of 30/70 the freezing temperature continues to climb. The following phase diagrams help explain how the freezing point (eutectic temperature) of common deicing chemicals will change when mixed at different concentrations.

Phase Diagrams of Five Brines

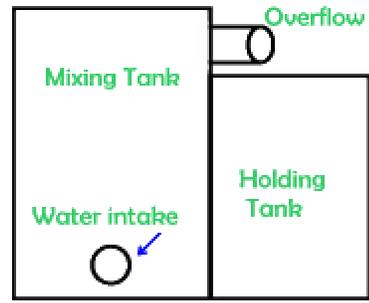


The hydrometer is actually the device that measures the specific gravity of a solution in water but for our purposes it basically measures the percent concentration of salt in the brine solution. The following is a specific gravity chart for brine and a conversion to the percentage of solution and a salimeter reading using a readout on a scale of 0-100% solution.

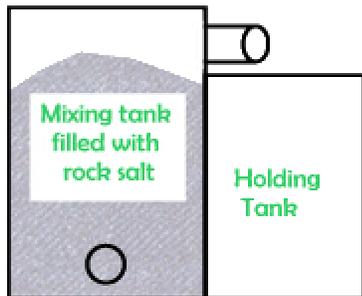
% of salt	Hydrometer Specific Gravity	Hydrometer (Salimeter) using 0-100%
0	1	0%
1	1.007	4%
2	1.014	7%
3	1.021	11%
4	1.028	15%
5	1.036	19%
6	1.043	22%
7	1.051	26%
8	1.059	30%
9	1.067	33%
10	1.074	37%
11	1.082	41%
12	1.089	44%
13	1.097	48%
14	1.104	52%
15	1.112	56%
16	1.119	59%
17	1.127	63%
18	1.135	67%
19	1.143	70%
20	1.152	74%
21	1.159	78%
22	1.168	81%
23	1.176	85% -----Ideal solution level
24	1.184	89%
25	1.193	93%
26	1.201	96%
27		100%

The container you use can be as simple as a bucket. For this discussion, we will present several options – everything from a simple home made unit using locally available parts and purchased models of various designs and capacities. The City of Oskaloosa and Iowa DOT have used the home made version for their initial use of prewetting and anti-icing. As confidence and satisfaction grew in the techniques and use increased, the Iowa DOT progressed to more sophisticated purchased units with greater capacities. There are differences in the home made and the purchased models beyond price but both are capable of producing brine at 23.3%.

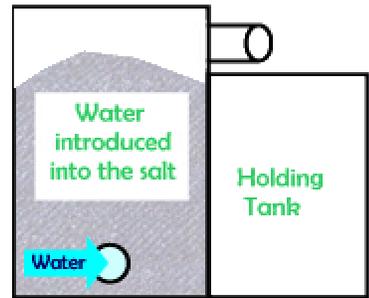
Simple Diagram of the brine making process in a purchased unit



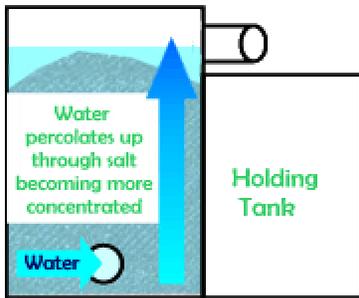
Basic components



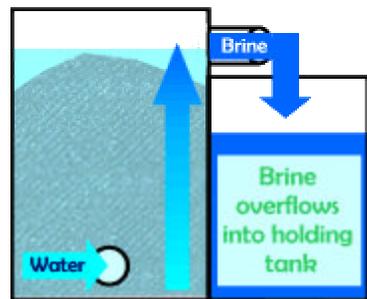
Step 1 – Add rock salt



Step 2 – Add water to the salt. A manifold or other type of mechanism controls the flow of water



Step 3 – As the controlled flow of water percolates up through the rock salt, the solution becomes more and more concentrated.



Step 4 - The liquid at the overflow level is at or near the 23% salt solution. The brine solution flows into the holding tank and is tested for the correct concentration using a hydrometer or salimeter.

If too dilute, the solution is recirculated back through the mixing tank.

Or, if too concentrated, additional water is added.

Once the concentration is correct at 23.3%, the brine can be used to refill anti-icing and prewetting tanks, or offloaded to storage tanks, ready to use when needed.

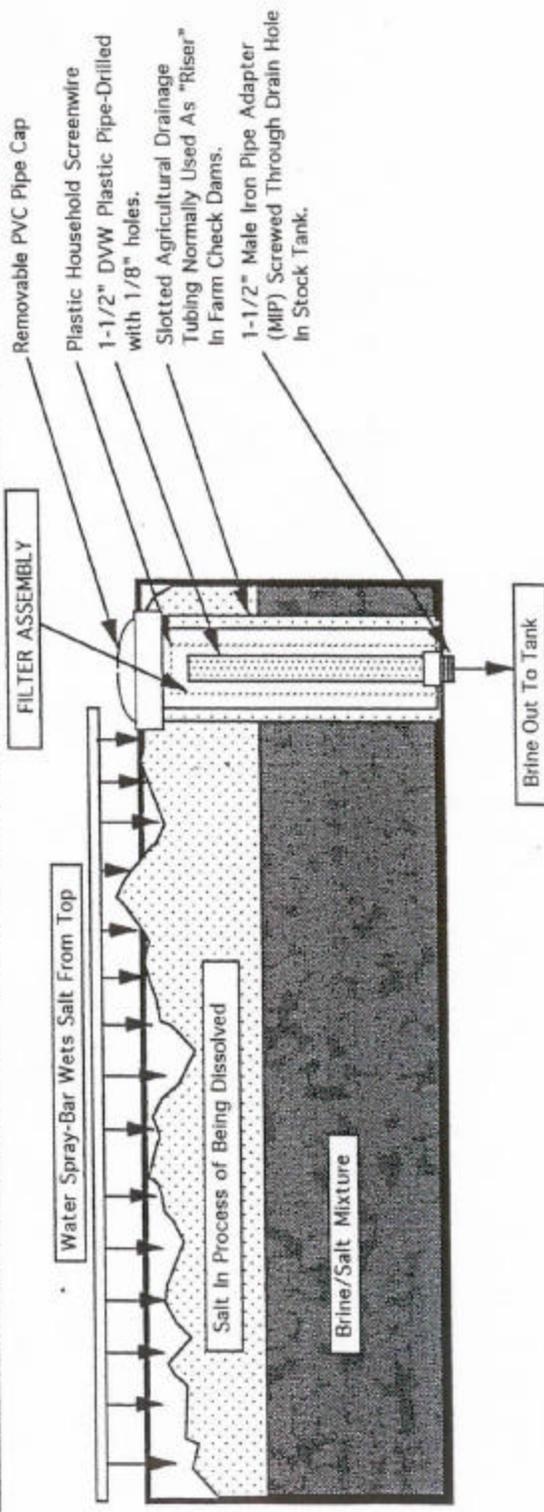
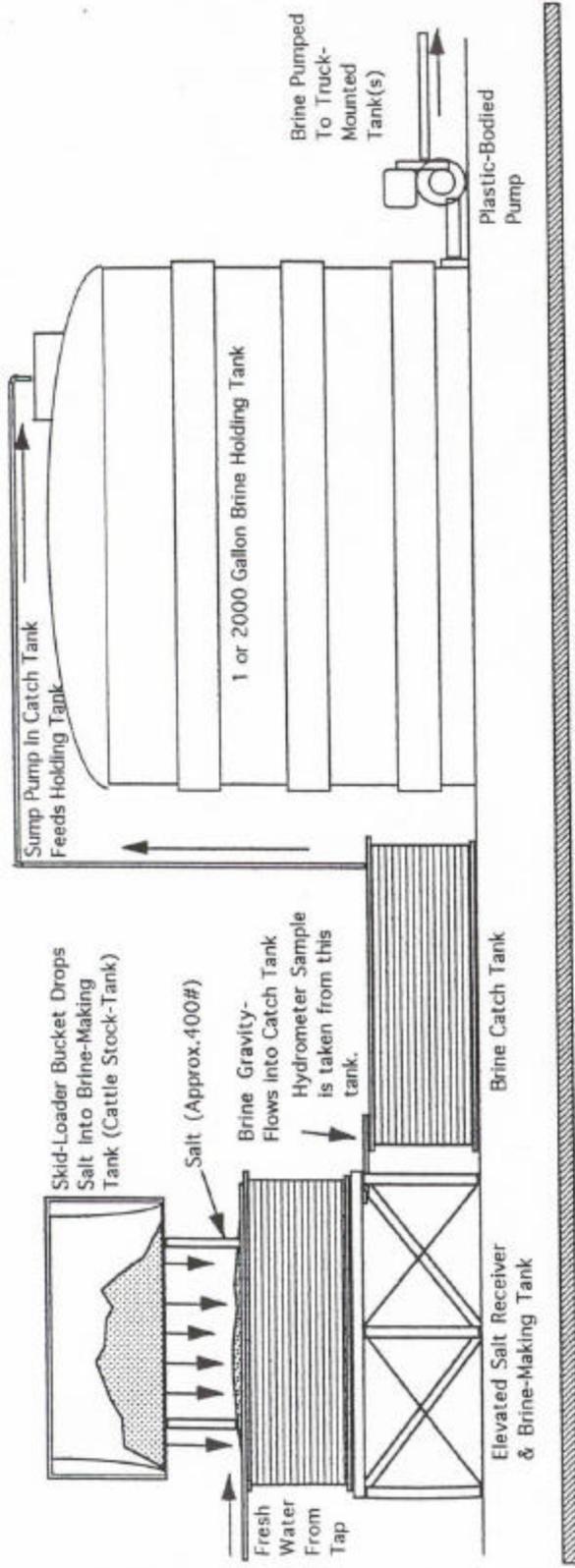
The following information is not an endorsement of any particular brand or product, but simply an account of the Iowa DOT's experiences as they moved from using no salt brine to using over 7 million gallons in a time span of 10 years or less.

The beginning – a homemade brine maker



The Iowa DOT's first locations to use salt brine constructed their own brine makers. All of the parts required to build a brine maker are readily available at any farm implement store. The bill for construction should be relatively small especially when considered in comparison to the material savings that can be gained from the use of brine. Typical cost for a home made brine making system using galvanized stock tanks is approximately \$600 excluding the cost of plastic storage tanks.

Plans for a homemade brine maker ([link](#))



"DOT-STYLE" BRINE MAKING SYSTEM

Purchased Brine Maker:

In 1995, the Iowa DOT purchased their first commercially produced brine makers when 32 units were purchased from VariTech Industries for use in garages with responsibility for Interstate highway maintenance. The brine makers were able to produce 600 gallons of brine in 40 minutes. Since then the department has purchased additional brine makers that have the ability to provide larger volumes faster than the original brine makers. Brine making speed and volumes are dependent primarily on the water supply. If you only have 1-inch water lines, brine making will be a much slower process than when a 2-inch supply line is available. The following are pictures of a number of brine makers that have been successfully used by the Iowa DOT, including the most current model (and specifications):



The original Varitech brine maker



Inside a Varitech brine maker



Sprayer Specialties brine maker



A mobile brine maker was constructed to travel to shops with low volume salt brine needs and/or for use at rural facilities with wells that would not support the volume of water needed to produce brine. Now most facilities have their own salt brine production units. If not, the brine is normally produced at a fixed location

and delivered via a tanker truck to outlying shops.



Brine facility with outside storage

Though Iowa's winter low temperatures occasionally fall below salt brine's freeze point (-6° F.) for short periods of times, brine produced at the correct concentration has never frozen. In one instance, a tank did freeze, but laboratory tests showed that the brine concentration was well below 23%.



A new model of VariTech brine maker. The tank on this brine maker was molded rather than welded plastic as the original units, but design is very similar.



Varitech VCSB 1400-SS brine maker

This is the current model of brine maker purchased by the Iowa DOT. The tanks are constructed of stainless steel. Production capacity is 5,000 gallons/hour.





The mixing tank can be easily lifted off using an end loader to dump out impurities and clean the tank.

If considering adding a brine making production plant to your facility, there are a few other lessons learned in the Iowa DOT's experience that you may want to be aware of or consider.

Water

- ❑ Water supply line size can limit production capabilities. A minimum of 2" supply line is recommended if substantial quantities of brine will be produced.
- ❑ Consider a separate water meter for the brine maker to avoid paying sewer charges on the water used to make brine
- ❑ Facilities with well water must carefully consider if the additional load required to make substantial quantities of brine can be "borne" by the natural water supply.

Salt

- ❑ Despite what you may think, very fine salt does not work well in brine makers. A standard gradation salt with as few impurities as possible is best.
- ❑ If salt is too fine, the water can con circulate freely through the salt, and you may end up with a lump of salt that will not appropriately go into solution.
- ❑ If impurities are allowed to build up in the mixing tank, it is more difficult to get a consistent, fully concentrated salt solution and production may suffer

Facilities - When siting a brine production facility, consider the corrosive nature of the salt and minimize those effects wherever possible.

- ❑ Consider a separate building or section off a portion of a building so that the corrosiveness can be controlled or contained. Separate heating and ventilation systems are recommended.
- ❑ Electrical connections and equipment are especially subject to corrosion. Investigate weatherproof switches, fans, etc. and consider mounting as much equipment as possible outside the building.

- ❑ Use moisture resistant lighting and encase all interior wiring in well sealed plastic conduit for protection.
- ❑ A standard overhead door will have a shortened life span due to the corrosive atmosphere. Consider the additional replacement expense down the road or investigate upgrades that may better withstand the corrosion.

Storage –

- ❑ Consider the need and/or local or state requirements for secondary containment
- ❑ Make sure that tanks to be used outdoors contain a UV inhibitor
- ❑ A gallon of salt brine weighs over 2 pounds more than a gallon of water. Make sure that the tanks you purchase are of sufficient strength to handle the additional weight.

Applying Brine

There are many ways to deliver the brine to the roadway. Again, the units can range from very small, inexpensive homemade units to large sophisticated pieces of equipment. Though there are many variations, the following photos demonstrate some of the prewetting and anti-icing equipment that has been successfully used by the Iowa Department of Transportation.

Prewetting units:



Home made 125 gallon prewet unit



Home made 100 gallon prewet unit



Another homemade unit (approx. 80 gal)
made from scavenged PVC pipe plus end caps



Swenson 140 gallon tailgate mounted prewet unit



Monroe tailgate mounted prewet unit with 180 gal. capacity



Integrated tailgate – Iowa DOT dump trucks are now purchased with an integrated tailgate. The tailgate is constructed of stainless steel and has a capacity to hold 225 gallons of brine. The tailgate operates identical to a traditional tailgate, swinging open to allow easy unloading.

Specifications



The integrated tailgate also includes a dual auger feature. The first auger breaks up any clumps in the material before they reach the feed auger, providing better reliability and less clogging.

Anti-icing units, anti-icing trailers, and combination units

The Iowa DOT has used a variety of equipment, dependent on the particular needs of a location. Slip in units, trailers, tankers, and hybrid combination units are all in use.

The hybrid combination units have more liquid capacity than a traditional prewet unit, yet less capacity than a stand alone anti-icer, yet still has the capacity for a quantity of dry material. The combo unit has both a prewet pump and an anti-icing spraybar.

A number of combo units are now in use or being field tested. The combination units provide maximum flexibility for treatment options:

- ❑ Use liquids for traditional prewetting of dry material (10-15 gal./ton)
- ❑ Traditional anti-icing of roadways or bridges (40-50 gal./lane mile)
- ❑ Any combination of the two – for example, on light snow pack, you could apply dry materials along with 40 gal. per lane mile of brine to get quick melting action and maximize the chemical concentration available for melting



Homemade 1800 gallon slip in unit

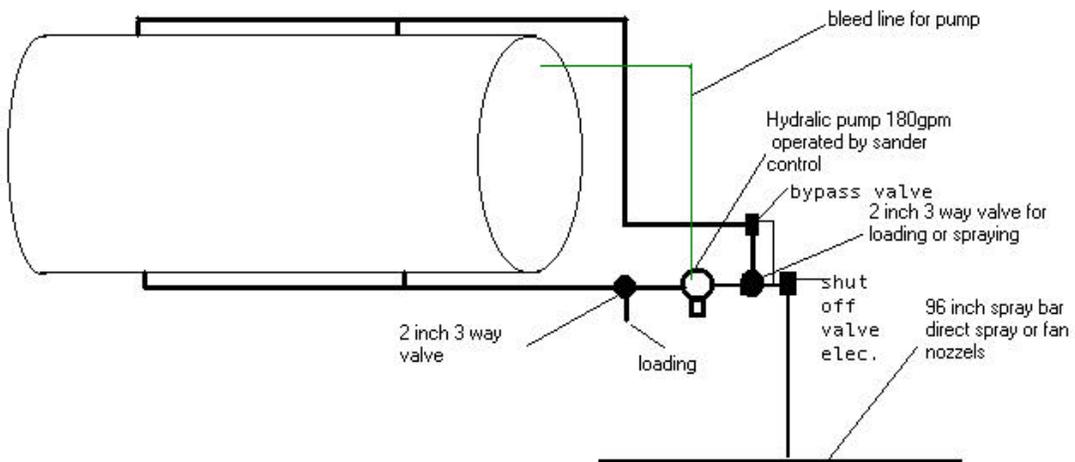


Homemade 1800 gallon slip in unit

Plans for slip in unit



Home made 250 gallon anti-icing unit.
This unit is used to treat for bridge frost



Presurize system controlled by sander control this system
will also load it self
estimated cost \$1,000



First anti-icer used in FHWA
TE-28 project in 1993 (no longer
in service)



1800 gallon homemade trailer mounted unit



2700 gallon trailer mounted homemade unit



3600 gallon homemade trailer mounted unit
(four 900 gallon tanks mounted on a lowboy
trailer that is used in summer to haul equipment,
but was sitting idle throughout the winter months)



Current anti-icing trailer with capacity of 1850 gallons



5000 gallon tanker trailer used to anti-ice Interstate



Home made combo unit with 900 gallon liquid capacity and 6 ton dry material capacity. Can apply dry, prewet or anti-icing/frost treatment



Another combo unit that uses 600 gal. stainless steel modular tanks in the truck bed. With this particular unit, the truck can be loaded with two tanks to carry 1200 gallons of liquid along with approx. 5 tons of dry material, or a third tank can be set into the truck bed and the truck then becomes strictly an anti-icing unit with 1800 gal. capacity.

Spray bars, nozzle configurations, splash control and other miscellaneous tidbits

A wide variety of different types of nozzles and spray bars have been used in the Iowa DOT's history with anti-icing. Some of the first units used were simple gravity fed units, where the size and number of holes drilled in the piping regulated the application rate. The current units are controlled by a Raven ground speed controller for precise, consistent application rates.

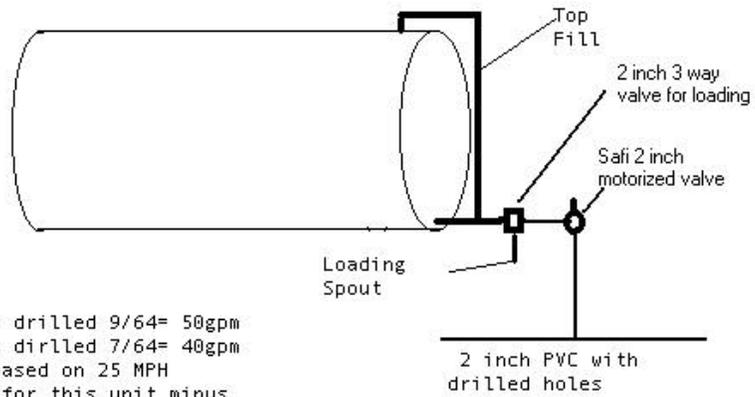
Fan nozzles were first used, some with the capability to spray multiple lanes. Most current units are designed to anti-ice a single lane and possible shoulder and are equipped with streamer nozzles to minimize the impact to traffic. All have been successfully used in different environments.



Simple homemade gravity fed unit
[Plans for gravity fed unit](#)



Fan spray nozzles in action. Nozzles mounted at the sides of the spray bar can be turned off or on to get wider lane coverage. Though fan nozzles can effectively and evenly cover a lot of pavement, there is some drift and misting. Fan nozzles are no longer recommended for new systems.



42 holes drilled 9/64= 50gpm
 42 holes drilled 7/64= 40gpm
 This is based on 25 MPH
 the cost for this unit minus
 the tank would be aprox.\$400

Gravity System with 96 inch bar



This unit has the capability to apply two different types of liquid deicers at the same time, such as liquid salt brine and liquid calcium chloride. The unit has separate tanks and pumps for each liquid.

Anti-icing and prewet to spinner on a combo unit



Fan and streamer combination



Clip on streamer nozzles



This anti-icing unit concentrates the deicer in the wheel path of the roadway. Three quarter inch hose barbs are used in place of a nozzle.



Rubber sheeting used as a windshirt to control drift



Inexpensive and easily replaced rubber tubing was attached to the spray bar to bring the brine very close to the road surface. This is currently in field testing and has promise for a simple inexpensive delivery system.

Conclusions:

Brine has shown to be an effective tool in the battle against snow and ice and should be carefully considered for use when preparing for winter storms. The percentage of salt in the brine solution is one of the keys to success with the use of brine. Too much salt and the freezing point goes up, too little and the freezing point also goes up.

The Iowa Department of Transportation used over 7,000,000 gallons of salt brine in the state last year for snow and ice control. The Department has equipped the entire fleet of 879 snow plow trucks with the ability to prewet all dry materials used in winter operations and last year had sufficient anti-icing equipment to anti-ice approximately 10,000 lane miles, including all of the Interstate.

The department continues to work with manufacturers and staff to continually improve the methods we use to deliver deicing chemicals on the roadway. Liquids may well be the most efficient method we have today to deliver quality service at lower costs with minimal impact to the environment.